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Design and Implementation of a Sophisticated Metal Detector Used in the Field of Airport Security

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ABSTRACT

In this research, we designed and implemented an advanced metal detector based on the Atmega328p microprocessor; it is used in the security field to prevent the entry of dangerous metal tools or explosives to places that require a high degree of safety such as schools, airports, universities and commercial malls. Where the mechanism of the electronic scheme of the detector was understood, including what it contains of active and passive electronic components, the microprocessor used how to program it and its technical specifications were identified. After that, we converted the electronic diagram into a printed circuit board (PCB) via easyada.com, And then print this circuit on special paper so that we can transfer it on the copper board, and a special solution was used to remove the copper residues from the board, after that holes were created and the electronic elements were soldered, Moving on to the software part, the Arduino Uno chip was used to act as an ISP programmer, through which the Atmaga328p controller was programmed using AVRDUDESS software, tested with a small coil with a diameter of 1.5cm. The detector gave excellent performance in detecting metal pieces such as copper, aluminum, iron and silver, as well as electrical wires in the walls, where the device screen shows the signal strength of the captured metal as well as the numerical symbol of the metal. It also discovered the presence of a sharp tool hidden in the mouth, shoes or inside the clothes, and the device achieved high performance In discovering metal parts and determining their properties, with an accuracy of 80%.

Keywords: *Atmega328p, Metal detector, Coil, Metal pieces, Metal numerical symbol.*

1. Introduction

A metal detector is an electronic device that detects metals close to it, and of course there are various and a different form of metal detectors belonging to various brands, and each of them has specific features. In the late nineteenth century, specifically in 1881, the first metal detector in history was made by the inventor and scientist Alexander Graham Bell. As for the uses of these devices, they were used in the past to detect mines in the ground, especially during the First and Second World Wars [1]-[2].

The matter did not stop with the invention of the portable metal detector, but the work continued to make metal detectors more convenient and easy to navigate and to make them enjoy modern and advanced features, and the invention of the transistor had a significant impact on the development of metal detectors and transferred them to a completely different space, as the emergence of Modern technologies and microprocessors have led to a qualitative leap in this field, as the design and development process has become simpler, to be used in security fields more widely and with high reliability.

In this paper, we talked about metal detectors and primitive techniques and modern techniques used, and we designed a metal detector circuit to study the frequency of some different metals such as aluminum, gold and silver, and compare the practical results with the theoretical results, as it was found that the practical results differ from the results The theory is due to the difference in temperature, the difference in hearing the sound of the device when we find the metal as a result of the difference in the noise ratio, as well as the quality of the device and its sensitivity [3]-[7].

2. Research Goal

The purpose of the design and implementation of the metal detector is to use it in the security field to prevent the entry of dangerous metal tools or explosives to places that require a high degree of safety, such as schools, airports, universities and commercial malls.

3. Importance of Research

(a) The detector is used to inspect when entering places that require a high degree of safety and security, such as airports, tourist places and prisons.

(b) These devices have become a requirement of safety and security in airports, universities, schools, theaters and government buildings to ensure that no armed persons enter these buildings.

(c) Detection of sharp metal objects in clothing.

4. Detector Electron Scheme

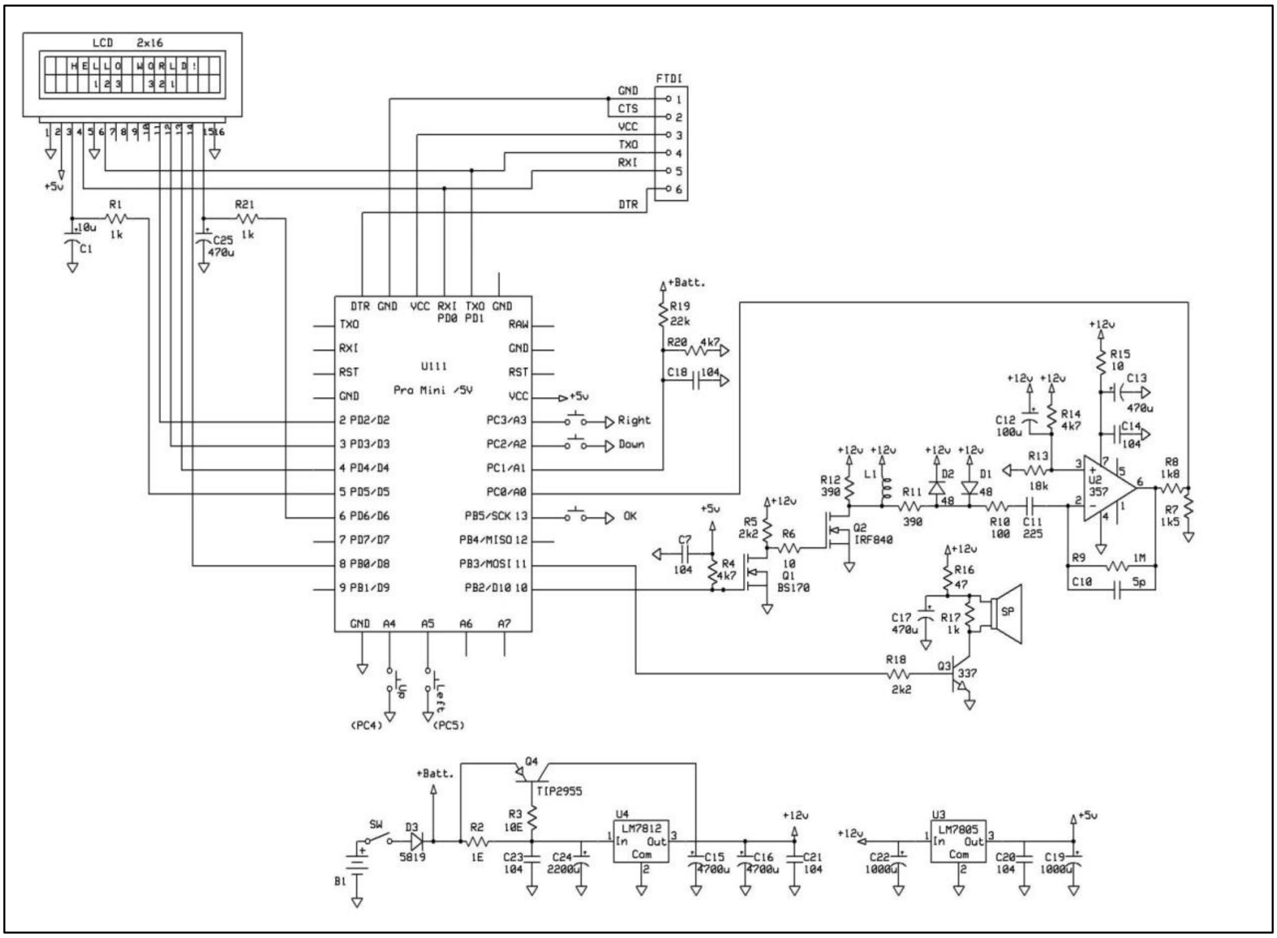

Figure 1. Electronic scheme of the design

The electronic diagram consists of the following components:

A. Capacitors.

B. Resistors.

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C. 5V and 12V voltage regulators.

D. Crystal 20MHz.

E. LF357N Operation Amplifier.

F. Transistors.

G. Diodes.

H. Atmega328p microcontroller.

I. LCD 16*2 display.

J. Speaker 8 ohm 0.2 watt.

K. 1.5 ohm 350 micro henry coil.

L. 18V_24V battery.

M. Momentary switches.

5. Working Principle of the Detector

Its working principle is based on Pulse Induction technology, where an electric current is generated from alkaline batteries or lithium-ion batteries that give strong and short pulses of current that are passed through a group of copper wires designed in the form of rings and each pulse generates a short magnetic field, and when the induction ends , the magnetic field reverses and fades, resulting in a sharp electrical surge that lasts a few microseconds and causes another current to pass through the coil, this current is called the reflected pulse and it is very short and lasts only about 30 microseconds and the process is repeated.

6. Design Stages

Initially, the PCB was designed via EASYADA.COM to get the following form:

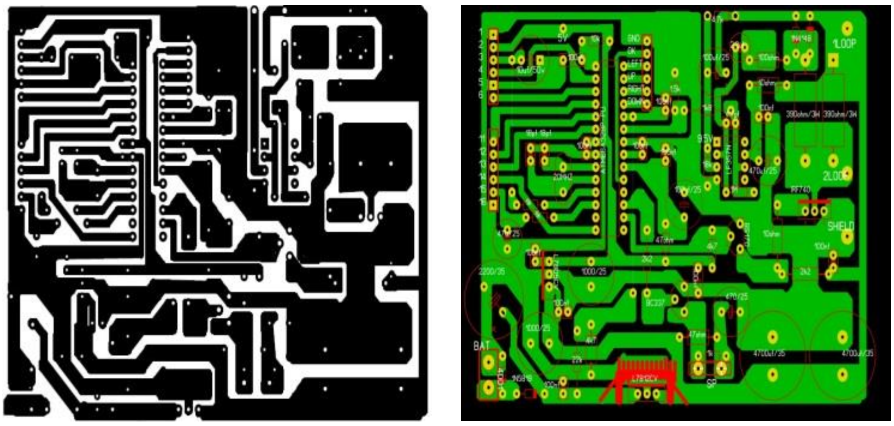

Figure 2. PCB - Printed circuit board

We printed the circuit on Glossy paper and transferred the rubber ink onto the copper board (PCB),The board was placed in a chemical solution to remove copper residues from the board.

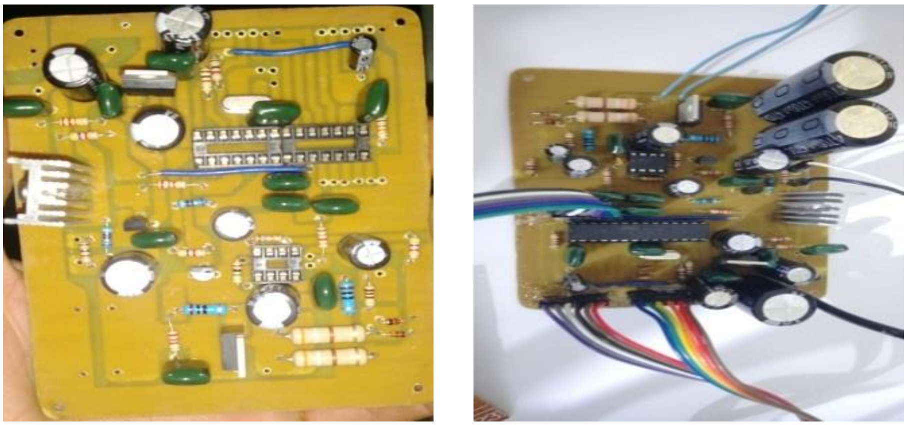

Figure 3. The Practical Electronic Circuit

7. Diagram for Programming

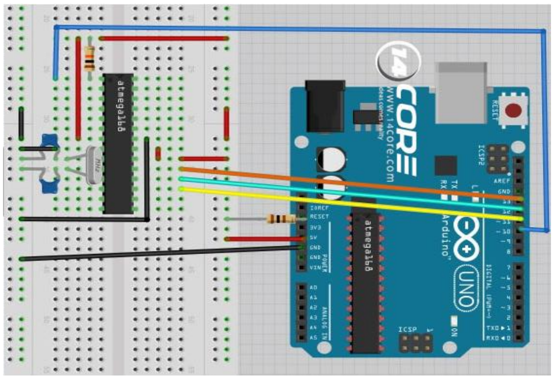

Figure 4. Connecting the microcontroller to the Arduino

(a) SPI MISO, MOSI and SCK electrodes are used to communicate, applying a voltage of 3.3v to the programmer and the target. (b) We used a 16mhz crystal placed in parallel with the xtal1 xtal2 terminals of the microcontroller to be programmed, to be grounded through two capacitors with a capacity of 22 Pico farads, in order to prevent noise in the pulses. (c) Putting a 100 ohm resistance between the reset pin of the Arduino and the positive terminal, and a 10 kilo ohm resistance between the reset pin of the microcontroller and the positive terminal. (d) Connect the pins (1,17,18,19) of the microcontroller to the pins (10, 11, 12, 13) of the Arduino and then we feed the microcontroller with 5v of the Arduino.

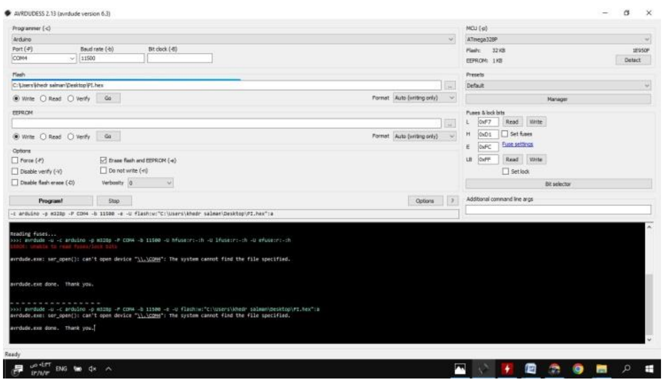

Figure 5. Programming the Arduino to act as an ISP programmer

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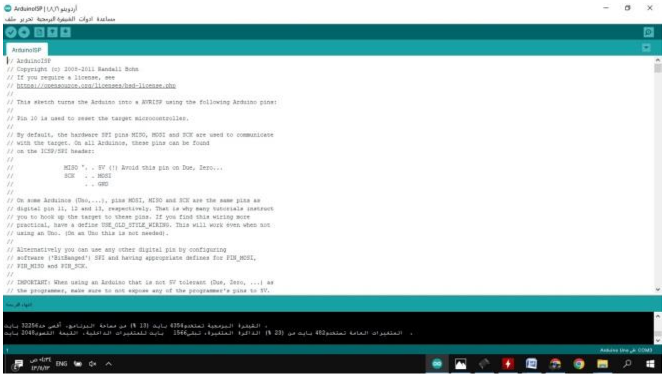

Figure 6. Passing the HEX file to the controller using the AVRDUESS program

8. Practical Results

The designed model was tested and the device achieved high performance in detecting metal parts and determining their characteristics with an accuracy of 80%.

The test was carried out using a small coil with a diameter of 1.5 cm, and it gave excellent performance in detecting metal pieces such as copper, aluminum, iron and silver, as well as electrical wires in the walls. The device screen shows the signal strength of the captured metal as well as the numerical symbol of the metal. Having a sharp object hidden in the mouth, shoes or inside clothing.

Figure 7. Detector

Figure 8. Detection of Aluminum

Figure 9. Detection of Iron

Figure 10. Detection of copper

Figure 11. Detection of battery

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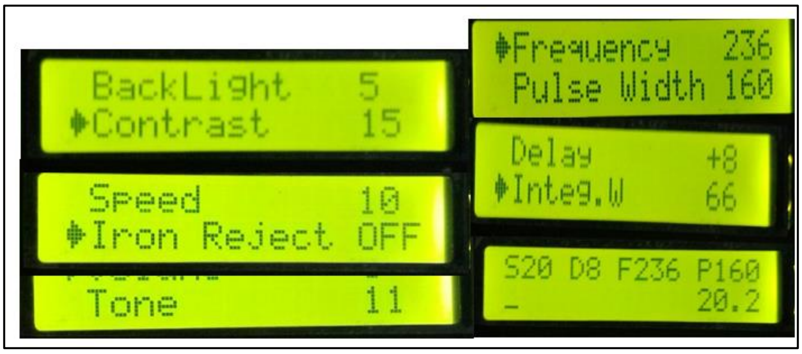

Figure 12. Detector setting

The device has many features, including:

A. The ability to raise and lower sensitivity.

B. Frequency change feature.

C. Adjustable pulse width.

D. The ability to adjust the time delay.

E. Adjust screen contrast.

F. Adjustment of the backlight of the screen.

G. Raise and lower the volume.

H. Change the type of sound.

I. Knowledge of the mineral (metal numerical code ID 0_99).

J. Automatic calibration of the device.

K. Correction factor.

L. Adjust the speed of the sensor.

M. Possibility to increase the diameter of the coil and thus increase the range.

The main problem with this device is its sensitivity to the soil and its instability in working on it, as the soil contains metal oxides, which in turn causes interference with the work of the device. It is better to develop this device to work in various conditions**.**

Declarations

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Competing Interests Statement

The authors declare no competing financial, professional and personal interests.

Consent for publication

Authors declare that they consented for the publication of this research work.

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